March 25, 2003

Dr. John A. Bernard, Director
Nuclear Reactor Laboratory
Massachusetts Institute of Technology
138 Albany Street
Cambridge, MA 02139-4296

SUBJECT: MASSACHUSETTS INSTITUTE OF TECHNOLOGY - AMENDMENT RE: FISSION CONVERTER SURVEILLANCE REQUIREMENTS (TAC NO. MB3761)

Dear Dr. Bernard:

The U.S. Nuclear Regulatory Commission (Commission) has issued the enclosed Amendment No. 34 to Amended Facility Operating License No. R-37 for the Massachusetts Institute of Technology Research Reactor (MITR). The amendment consists of changes to the Technical Specifications (TSs) in response to your application of November 21, 2001, as supplemented on October 15 and December 10, 2002.

The amendment eliminates the annual requirement for calibration of the fission converter tank coolant level channel and modifies the requirement for measurement of the fission converter tank pH.

A copy of the safety evaluation supporting Amendment No. 34 is also enclosed.

Sincerely,

/RA/

Alexander Adams, Jr., Senior Project Manager
Research and Test Reactors Section
Operating Reactor Improvements Program
Division of Regulatory Improvement Programs
Office of Nuclear Reactor Regulation

Docket No. 50-20

Enclosures: 1. Amendment No. 34
2. Safety Evaluation

cc w/enclosures:
See next page

Massachusetts Institute of Technology

Docket No. 50-20

cc:

City Manager
City Hall
Cambridge, MA 02139

Department of Environmental Quality Engineering
100 Cambridge Street
Boston, MA 02202

Test, Research, and Training Reactor Newsletter
University of Florida
202 Nuclear Sciences Center
Gainesville, FL 32611

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MASSACHUSETTS INSTITUTE OF TECHNOLOGY

DOCKET NO. 50-20

AMENDMENT TO AMENDED FACILITY OPERATING LICENSE

Amendment No. 34
License No. R-37

1. The U.S. Nuclear Regulatory Commission (the Commission) has found that

   A. The application for an amendment to Amended Facility Operating License No. R-37 filed by the Massachusetts Institute of Technology (MIT or the licensee) on November 21, 2001, as supplemented on October 15 and December 10, 2002, conforms to the standards and requirements of the Atomic Energy Act of 1954, as amended (the Act), and the regulations of the Commission as stated in Chapter I of Title 10 of the *Code of Federal Regulations* (10 CFR);

   B. The facility will operate in conformity with the application, the provisions of the Act, and the rules and regulations of the Commission;

   C. There is reasonable assurance that (i) the activities authorized by this amendment can be conducted without endangering the health and safety of the public and (ii) such activities will be conducted in compliance with the regulations of the Commission;

   D. The issuance of this amendment will not be inimical to the common defense and security or to the health and safety of the public;

   E. This amendment is issued in accordance with the regulations of the Commission as stated in 10 CFR Part 51, and all applicable requirements have been satisfied; and

   F. Prior notice of this amendment was not required by 10 CFR 2.105 and publication of a notice for this amendment is not required by 10 CFR 2.106.

2. Accordingly, the license is amended by changes to the Technical Specifications as indicated in the enclosure to this license amendment, and paragraph 2.C.(2) of Amended Facility Operating License No. R-37 is hereby amended to read as follows:

   (2) Technical Specifications

   The Technical Specifications contained in Appendix A, as revised through Amendment No. 34, are hereby incorporated in the license. The licensee shall operate the facility in accordance with the Technical Specifications.

3. This license amendment is effective as of the date of its issuance.

FOR THE NUCLEAR REGULATORY COMMISSION

/RA/

Patrick M. Madden, Chief
Research and Test Reactors Section
Operating Reactor Improvements Program
Division of Regulatory Improvement Programs
Office of Nuclear Reactor Regulation

Enclosure:
Appendix A, Technical
Specifications Changes

Date of Issuance: March 25, 2003

ENCLOSURE TO LICENSE AMENDMENT NO. 34

AMENDED FACILITY OPERATING LICENSE NO. R-37

DOCKET NO. 50-20

Replace the following pages of Appendix A, "Technical Specifications," with the enclosed pages. The revised pages are identified by amendment number and contain vertical lines indicating the areas of change.

Remove	Insert
6-56	6-56
6-59	6-59

6.6.2.6 Fission Converter Primary Coolant Quality Requirements

Applicability

This specification applies to the pH, conductivity, and activity of the fission converter primary coolant.

Objective

To control corrosion of the fission converter fuel and primary coolant loop structure, and activation of impurities and leakage of fission products in the fission converter primary coolant.

Specification

1. The pH of the fission converter primary coolant shall be kept between 5.5 and 7.5, except as noted in provision (4) below.
2. The conductivity of the fission converter primary coolant shall be kept less than 5 μS/cm at 20°C, except as noted in provision (4) below.
3. Any gross ß-γ sample activity that exceeds the average of the previous monthly values (normalized by power) by a factor of three or more shall be investigated to determine the cause.
4. Operation of the fission converter with the pH or conductivity outside the limits given in (1) and (2) above is permitted provided:
   a. the pH is between 5.0 and 8.0,
   b. any increase in conductivity is not the result of a chloride ion concentration in excess of 5 ppm,
   c. sampling of the fission converter coolant is done at least once every eight hours, and
   d. the pH band specified in provision (1) is re-established with 48 hours.

   Otherwise, the fission converter shall not be operated.

Amendment No. 34
March 25, 2003

a. Neutron flux level channel,

b. Primary coolant flow channel, and

c. Primary coolant outlet temperature channel

3. The neutron flux level channel and a fission converter primary system heat balance shall be checked against each other at least annually and when design changes in the reactor and/or the fission converter are made that may affect the existing calibration result.

4. The gross β-γ activity of the fission converter primary coolant shall be determined at least monthly. The conductivity of the fission converter primary coolant shall be determined either by a continuous on-line instrument or a monthly sample. The pH of the fission converter primary coolant shall be measured monthly if the average conductivity exceeds 0.10 μS/cm if H_2O is used as a coolant or 0.03 μS/cm if D_2O is used as a coolant. The tritium content of the coolant shall be determined quarterly if D_2O is used as the fission converter primary coolant.

5. The following instruments used in the fission converter shall be subject to a functional test when initially installed, any time that the instrument has been repaired, and at least annually:

   Fission Converter tank coolant level channel

Basis

The specification for functional tests, calibrations, and primary coolant sampling adhere to current MITR practice.

The annual frequency for performance of the calorimetric was chosen because the fission converter's power is a function of the MITR's power and the burnup of the fission converter fuel. The latter will occur very slowly. Hence, the annual performance of a calorimetric is sufficient to detect any change in fission converter power production.

Experience with the MITR primary and D_2O systems has shown that an out-of-specification chemistry condition is extremely rare. Heat fluxes present in the fission converter are too low to contribute to fuel cladding degradation in the event of out-of-specification chemistry. Continued operation of the fission converter is thus permitted.

SAFETY EVALUATION BY THE OFFICE OF NUCLEAR REACTOR REGULATION

SUPPORTING AMENDMENT NO. 34 TO

AMENDED FACILITY OPERATING LICENSE NO. R-37

MASSACHUSETTS INSTITUTE OF TECHNOLOGY

DOCKET NO. 50-20

1.0 INTRODUCTION

By letter dated November 21, 2001, as supplemented on October 15 and December 10, 2002, the Massachusetts Institute of Technology (MIT or licensee) submitted a request for amendment of the Technical Specifications (TSs) for Amended Facility Operating License No. R-37 for the MIT Research Reactor (MITR). The requested changes would eliminate the annual requirement for calibration of the fission converter tank coolant level channel and modify the requirement for measurement of the fission converter tank pH.

2.0 BACKGROUND AND EVALUATION

Amendment No. 31 to the MIT license, issued on December 21, 1999, authorized the operation of a fission converter at the MITR to produce a beam of neutrons for the conduct of boron neutron capture therapy. The beam design is based on a fission converter driven by neutrons from the MITR. Thermal neutrons from the reactor are “converted” to neutrons with a fission spectrum by the fission converter. This subcritical multiplication of the reactor neutron flux results from fissioning of the uranium loaded into the fission converter. A filter/moderator is used to tailor the neutron beam by eliminating unwanted fast neutrons and photons without significantly decreasing the useful epithermal neutrons. The fission converter consists of MITR fuel elements placed on a grid and enclosed in a fission converter tank. A collimator and a system of shutters are used to deliver the beam to a patient located in the shielded medical therapy room. A converter control shutter (CCS) is used to control the flow of the thermal reactor neutrons to the fission converter. When the CCS is open, thermalized reactor neutrons can reach the converter. The converter fuel is cooled by natural or forced convection of water or heavy water in the fission converter tank. The licensee is currently using heavy water.

The licensee has requested two changes related to surveillance requirements for the fission converter. The regulation in 10 CFR 50.36(c)(3) requires TSs to contain surveillance requirements. Surveillance requirements are requirements relating to test, calibration, or inspection to assure that the necessary quality of systems and components is maintained, that facility operation will be within safety limits, and that the limiting conditions for operation will be met.

The first requested change would eliminate subsection (d), a requirement to perform calibrations of the fission converter tank coolant level channel, from TS 6.6.3.2. The TS reads as follows:

2. The following instruments used in the fission converter facility shall be calibrated and trip points verified when initially installed, any time the instrument has been repaired, and at least annually:

    a. Neutron flux level channel,
    b. Primary coolant flow channel,
    c. Primary coolant outlet temperature channel, and
    d. Fission converter tank coolant level channel.

In addition to eliminating the requirement for the periodic calibration, the TS as proposed by the licensee also eliminated the calibration requirement after initial installation and repairs. In a request for additional information, the NRC staff asked the licensee to discuss this issue. In response, the licensee has proposed adding a new TS 6.6.3.5, which reads as follows:

5. The following instruments used in the fission converter shall be subject to a functional test when initially installed, any time that the instrument has been repaired, and at least annually:
    Fission Converter tank coolant level channel

The height of the coolant above the converter fuel needs to be controlled to ensure the integrity of the fuel cladding. The coolant also helps to moderate the energy of the neutrons to the energy needed to conduct therapy. If the coolant level drops too low, the coolant level channel detects the drop and the reactor is automatically scrammed and the converter control shutter is automatically closed. A signal from a float switch is used to determine if the coolant level has dropped to unacceptable levels. The licensee has requested elimination of the annual calibration of the coolant level float switch based on experience gained during operation of the fission converter and the design of the switch. As stated in proposed TS 6.6.3.5, the licensee will perform a functional test of the switch upon initial installation of a new switch, following repair of the switch, and at least annually. TS 6.6.3.1 also requires that a functional test of the automatic CCS closure and reactor scram from the fission converter tank coolant level channel be performed monthly and each time before startup of the reactor if the reactor has been shut down more than 16 hours and if the fission converter facility will be used within the reactor operating period.

The licensee states that the calibration is not necessary due to the design of the float switch which provides the level signal. The position at which the switch actuates is not adjustable. The switch actuation position is set by the position at which the switch is bolted to the fission converter tank. The mechanical operation of the switch setting is not subject to drift, which is normally compensated for by periodic calibration. However, the switch could be subject to a failure which could cause a loss of function. The licensee will continue to perform a functional test of the float switch as required by TS 6.6.3.1 and the proposed new TS 6.6.3.5. The functional test involves introducing helium gas into the annular space around the switch float. This causes the coolant level around the float to drop and activates the switch and associated circuits. This test would indicate if there was a failure of the switch. In addition, there are other

methods available to the licensee to detect a drop of coolant level in the fission converter tank. The coolant level in the tank is indicated on a digital coolant level indicator, which would give an indication of a change in coolant level. Also, a drop in coolant level would result in an increase in the radiation levels above the fission converter, which would be detected. Finally, a loss of coolant from the fission converter would lead to a low coolant flow condition, which would result in a reactor scram and CCS closure.

Calibrations that have been performed to date have shown no change in the actuation point position of the float switch.

For the reasons discussed above, the staff finds that the switch design is not subject to drift over time and does not require calibration and that the periodic functional tests currently performed and proposed by the licensee would acceptably test operability of the switch. In addition, functional testing at the time of initial switch installation and after repair gives reasonable assurance that new and repaired switches will preform acceptably. Therefore, the NRC staff concludes that the removal of the requirement from the TSs to perform an annual calibration of the coolant level float switch is acceptable, and that the requirements of 10 CFR 50.36(c)(3) continue to be met.

The licensee has requested changes to TS 6.6.3.4, which contains surveillance requirements for the pH of the fission converter coolant. The TS reads as follows:

> 4. The pH and gross β-γ activity of the fission converter primary coolant shall be determined at least monthly. The conductivity of the fission converter primary coolant shall be determined either by a continuous on-line instrument or a monthly sample. The tritium content of the coolant shall be determined quarterly if D_2O is used as the fission converter primary coolant.

The high purity of the coolant makes measurements of pH difficult. The licensee has proposed changing the TS as follows:

> 4. The gross β-γ activity of the fission converter primary coolant shall be determined at least monthly. The conductivity of the fission converter primary coolant shall be determined either by a continuous on-line instrument or a monthly sample. The pH of the fission converter primary coolant shall be measured monthly if the average conductivity exceeds 0.10 μS/cm if H_2O is used as a coolant or 0.03 μS/cm if D_2O is used as a coolant. The tritium content of the coolant shall be determined quarterly if D_2O is used as the fission converter primary coolant.

The licensee has proposed measuring the pH only if fission converter coolant conductivity exceeds 0.10 μS/cm for H_2O coolant or 0.03 μS/cm for D_2O coolant. The fission converter primary coolant pH range in TS 6.6.2.6 is 5.5 to 7.5 and the limit on conductivity is less than 5 μS/cm at 20 °C. However, the fission converter can be operated with pH and conductivity outside these limits provided (1) the pH is between 5.0 to 8.0, (2) any increase in conductivity is not the result of a chloride ion concentration in excess of 5 ppm, (3) the coolant is sampled every 8 hours, and (4) the pH band (5.5 to 7.5) is reestablished within 48 hours.

The coolant is continuously circulated through a cleanup loop, which results in very pure heavy water coolant with weak ionic strength. The pH of the coolant is measured using a batch sample and a commercially available kit to adjust the ionic strength. However, the treated coolant cannot be returned to the fission converter, creating radioactive waste and using valuable heavy water. The conductivity of the coolant is normally measured on-line. A relationship between conductivity and pH can be calculated. The licensee has presented curves based on references in the literature ("Handbook of Power Plant Chemistry," Hans-Gunter Heitmann, CRC Press, Boca Raton, 1993, for light water, and "An Introduction to CANDU Chemistry," D. Barber and J.P. Van Berlo, AECL CANDU, March 1994, for heavy water) that show the relationship between conductivity and pH in water systems. For example, for a conductivity of 0.10 µS/cm for light water, the pH range is about 6.6 to 7.5. As conductivity decreases, the pH range also decreases. Therefore, the curves show that if the conductivity is maintained below 0.10 µS/cm, the pH TS limits will be met for light water. Similarly, for heavy water, if the conductivity is maintained below 0.03 µS/cm, the pH limits will be met. In response to a request for additional information from the NRC staff, the licensee plotted actual conductivity-pH measurements they have taken of the converter coolant. The data shows reasonable agreement with the curves.

For the reasons discussed above, the staff finds that the licensee has proposed an acceptable method to determine the relationship between pH and conductivity. If fission converter coolant conductivity increases to levels that could result in pH being out of specification, actual pH measurements will be taken. Therefore, the staff concludes that the proposed changes to TS 6.6.3.4 are acceptable, and that the requirements of 10 CFR 50.36(c)(3) continue to be met.

The licensee has proposed a change to TS 6.6.2.6.2 concerning conductivity of the fission converter coolant. The proposed change would change the units of conductivity in the TS from µmho/cm to µS/cm. The reason for this change is to have consistent conductivity units within the TSs. This change clarifies the TSs and is acceptable to the staff.

3.0 ENVIRONMENTAL CONSIDERATION

This amendment involves changes in the installation or use of a facility component located within the restricted area as defined in 10 CFR Part 20 or changes in inspection and surveillance requirements. The staff has determined that this amendment involves no significant increase in the amounts, and no significant change in the types, of any effluents that may be released off site, and no significant increase in individual or cumulative occupational radiation exposure. In addition, as set forth below, the staff has concluded that the amendment involves no significant hazards consideration. Accordingly, this amendment meets the eligibility criteria for categorical exclusion set forth in 10 CFR 51.22(c)(9). Pursuant to 10 CFR 51.22(b), no environmental impact statement or environmental assessment need be prepared in connection with the issuance of this amendment.

4.0 CONCLUSION

The staff has concluded, on the basis of the considerations discussed above, that (1) the amendment does not involve a significant increase in the probability or consequences of accidents previously evaluated, or create the possibility of a new or different kind of accident from any accident previously evaluated, and does not involve a significant reduction in a margin of safety, the amendment does not involve a significant hazards consideration; (2) there is reasonable assurance that the health and safety of the public will not be endangered by the proposed activities; and (3) such activities will be conducted in compliance with the Commission's regulations and the issuance of this amendment will not be inimical to the common defense and security or the health and safety of the public.

Principal Contributor: A. Adams, Jr